

ED SMAER

Sujet de thèses 2013

Laboratoire : ISIR – *Institut des Systèmes Intelligents et de Robotique*

Etablissement de rattachement : UPMC

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Titre de la thèse : Chaîne de téléopération multi-axes pour la micro/nano robotique
Interactive mulit-dof and tool remote handling for micro & nano robotics

Collaborations dans le cadre de la thèse : Percipio Robotics, Femto-ST, IEMN

Le sujet peut être publié sur le site web de l'ED SMAER : OUI

Résumé du sujet :

L'ISIR a développé une chaîne de micro téléopération stable et transparente pour tous gains de changement d'échelle dont le caractère innovant et la performance ont été démontrés sur un prototype fonctionnel à un axe. Il s'agit dans cette thèse de concevoir une nouvelle gamme d'interface haptique à plusieurs degré de liberté, de concevoir des sondes à plusieurs ddl basés sur une mesure embarquée des déplacements (par exemple capacitive ou piézorésistive). Il a aussi nécessaire développer l'environnement interactif pour le l'interaction homme/robot trans-échelle, en utilisant des approches de réalité virtuelle/augmentée et de couplage haptique. Le champ applicatif visé est la caractérisation ou la manipulation d'échantillons artificiels (comme des microcomposants) ou biologiques comme des cellules par exemple.

Chaine de téléopération multi-axes pour la micro/nano robotique

Interactive multi-dof and tool remote handling for micro & nano robotics

Human interaction with micro-scale is an important challenge in microrobotics. Fields like biology and nanotechnologies, especially for characterization of new materials, for design of micro/nano-systems or analysis of physical micro-scale phenomena present complex challenges beyond the possibilities of automated systems. In those cases, guidance from a human operator is required to carry out the task.

However, this interaction is hardly straightforward. The human operators cannot interact directly with micro-scale because of the scale of treated objects and applied forces. Moreover, the resolution of optical microscopes is limited and the Scanning Electronic Microscope (SEM) do not provide real time images. Systems are sensitive to environmental conditions, for example temperature and humidity. Indeed, the micro/nano scale physics differs from macro world: mechanical behavior is no longer dictated by gravity force and short range forces such as electrostatic, capillary and van der Waals forces dominate [Sitti-1999]. Consequently, the physics of the micro-scale differs completely from that of the macro-scale perceptible by human. Thus, the understanding of this scale cannot be carried out by simple homothety of macro-scale and requires a special attention. Teleoperation in this case appears to be an interesting and promising solution to supplement human operators perception [Hollis-1990] [Hatamura-1990]. Its success requires to guarantee two important proprieties, transparency and stability. The first propriety quantifies the system's capacity to accurately convey the microscopic interaction to human operators. The second is a necessary condition because unstable system may cause damages on used tools or treated objects.

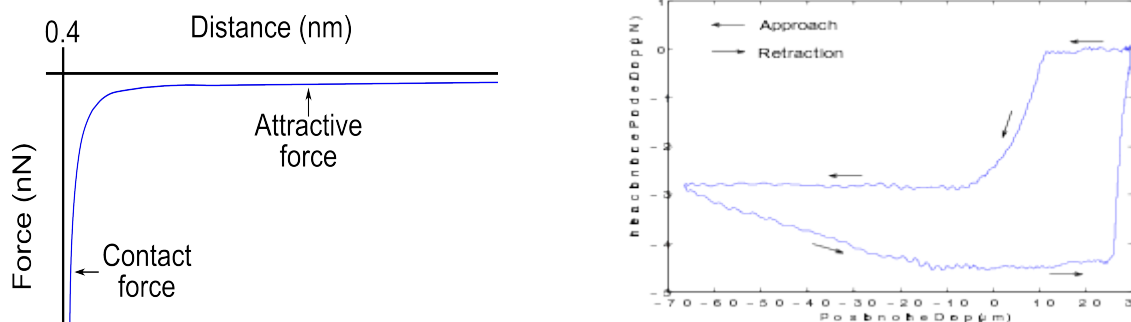


Fig:1 Theoretical profile of the adhesion force vs its experimental measurement with an AFM probe. The difference in these two cases is caused by the dynamics and basic principle of AFM.

Since 1990s, several micro-teleoperation systems are proposed to provide humans a sense of touch and manipulation capabilities at micro-scale. For example, in [Sitti-1999] a haptic device is connected with Atomic Force Microscope (AFM) for feeling and manipulating nano objects. [Schmid-2012] presents a coupling of a 3D micro-manipulator with haptic interface. Another micro tele-operation system was developed in [Mehrtaash-2011] around a magnetic untethered microrobotic and a haptic device using a bilateral coupling. They allow to extend human touch to micro/nano scales. This is achieved by direct or indirect coupling of an haptic interface, called the master device, and a micro-manipulation tool, called the slave device.

Despite their good performances, few of them provide a natural feel of microscopic interactions. In fact, it is difficult to guarantee at the same time the stability and transparency of the micro-teleoperation system. For example small forces are not transmitted. Stability and transparency are generally affected by the nature of the haptic interface and tools used. Moreover, problems of friction, inertia, hysteresis and noise tend to degrade the feel of such systems.

To overcome those limitations, a new threefold approach is developed by ISIR. These approach is established in previous works and consists of development of individual components of a teleoperation chain desgined from the ground to optimize the transparency and stability. As such, a novel single-axis force probe [Mohand-Ousaid-2013], a (single-axis) high fidelity haptic interface [Millet-2009] and bilateral coupling schemes [Bolopion-2010] are proposed.

The objective of this PhD work consists of design, realization, experimentation and validation of complete remote handling toolchain.

In this aim, the first step will focus on enhancements and improvements of initial designs of aforementioned components. Especially, a significant difficulty is to combine several degrees of freedom in the same tool capable of both sensing and manipulating.

Subsequently, a full human interaction scheme needs to be developed including haptic feedback and virtual or augmented reality approaches. In these prospects, design goals will be defined in the context of industrial collaborations and commercial viability concerns.

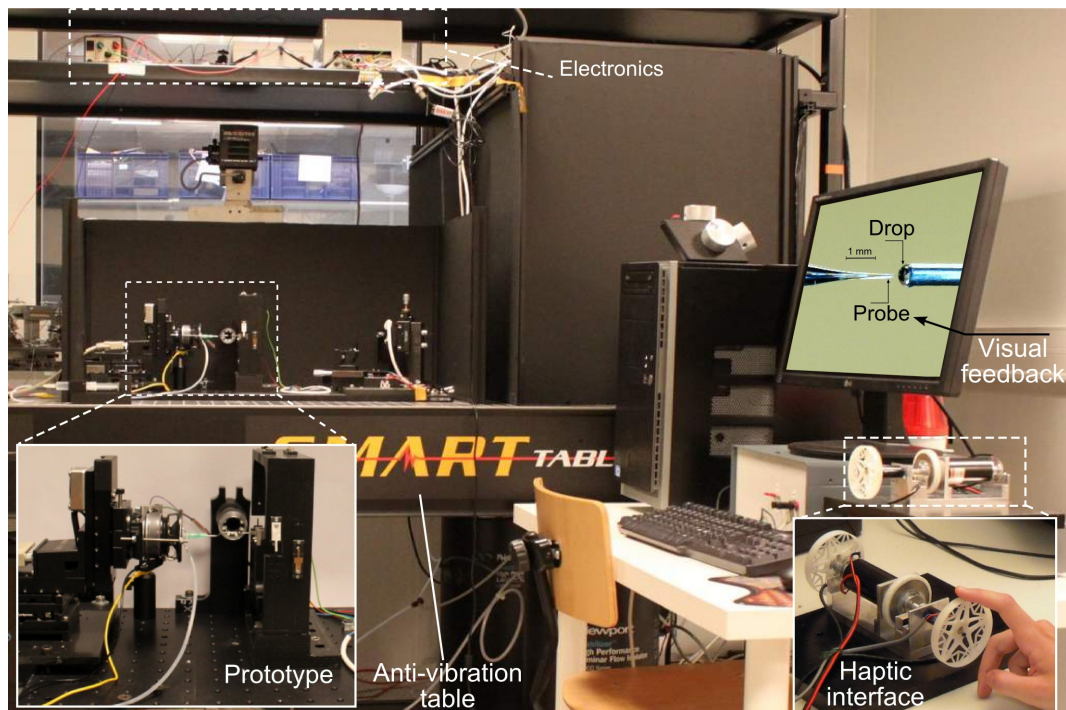


Fig.2 : *Experimental setup for microscale force probing. This single-axis setup is a proof of concept of the aproach to be developed in this PhD project.*